In-situ X-ray monitoring of advanced metallurgical processes under microgravity and terrestrial conditions (XRMON)

Experiments on the metal foams scheduled on the 46th ESA Parabolic Flight Campaign and preparation of MASER 11

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Introduction

For the preparation of the MASER 11 campaign and testing of the hardware system the need of a parabolic flight was identified. Also the microgravity tests should give information to the PI for the selection of the most appropriate sample for the sounding rocket campaign and how the metal foaming kinetics is influenced during microgravity. Moreover the parabolic flight should give scientific results observing the drainage and imbibition capability of the liquid metal foam during microgravity and during the transition from 0g to 1.8g.

The 46th ESA Parabolic Flight Campaign setup

The μG-furnace for foaming of metals provided by the Swedish Space Corporation (SSC) was tested with the X-ray system available at TU Berlin. The furnace was validated in Berlin and some small changes were performed to increase the reliability of the experiment. Further tests were performed by the PI at SSC with the flight setup, after it was completely mounted and ready for the PFC.

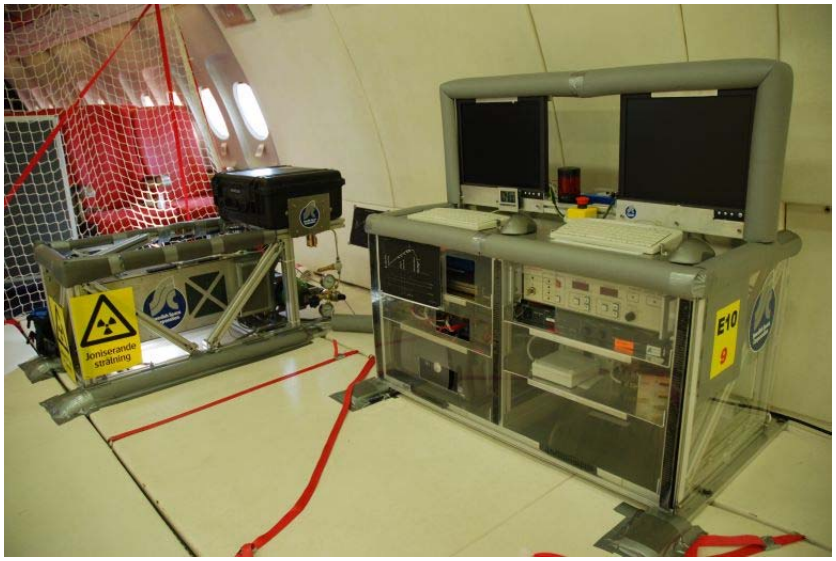

Figure 1: X-ray scanner with attached black box with 6 exchangeable metal foaming furnaces and control pool adapted for the PFC

The X-ray scanner and the control pool mounted on the airplane can be observed in Fig. 1. In order to have a maximum amount of experiments 6 furnaces were placed in a black box attached to the setup. They were charged with samples and exchanged them between each block of 5 parabolas. X-ray images of the experiments, temperature, gravity and further control parameters were recorded during the experiment (Fig. 2). Different temperature ramps were programmed in advance and selected from the PI in order to reach the metal foamed at the right time to exploit as much microgravity time as possible.

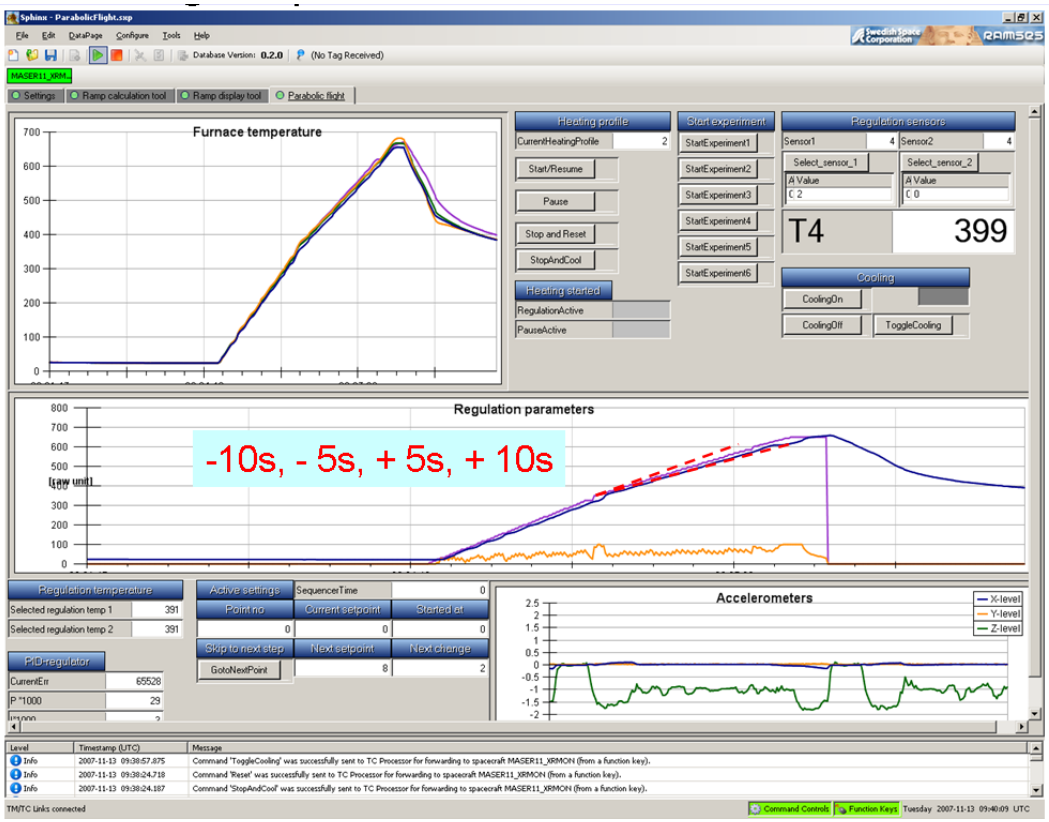

Figure 2: Display of the process controlling software

Test of hardware for MASER 11

The software and hardware was tested during the parabolic flight under microgravity conditions. Some discrepancy in the heating profiles was found compared to ground experiments, induced by the different gravity conditions and corresponding modified heat contact conditions between sample and crucible. This difference was found to be maximum ~ 5s to reach the end temperature, what will not be a problem for MASER 11 but was adjusted during the parabolic flight using the previously programmed temperature ramps.

One improvement of the furnace was found to be necessary and it was already implemented by SSC, improving the insulation of the heating wire. To avoid overpressure in the crucible, that will influence foaming, it was necessary to make an opening in it. Due to this opening liquid melt droplets can also come out and damage the furnace (see Fig. 3). Under microgravity this melt can damaged once during one experiment the heater. After improvement this problem cannot appear again during MASER 11.

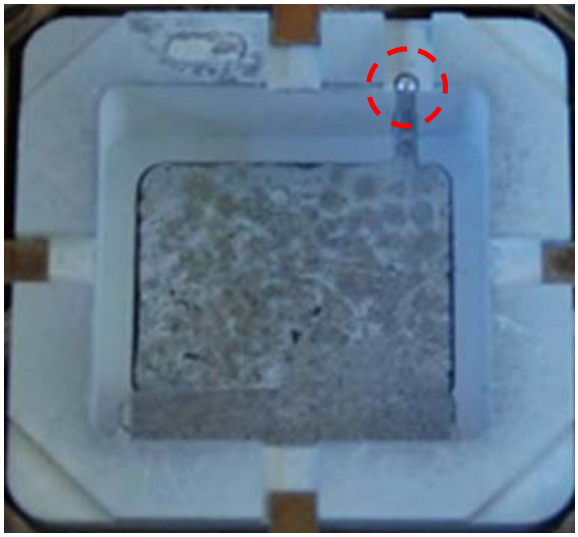

Figure 3: Crucible with expanded metallic foam. A metal droplet is marked on the upper right corner

Results under Microgravity

Although the flight was focused on testing the setup for MASER 11 some relevant results could be obtained. One of the most relevant results concerns the possibility to avoid drainage during microgravity and the rapid changes of the liquid metal through the cellular structure induced by gravity changes. As an example we can see in Fig. 4 how in just one second a large amount of liquid metal flows through the structure to the bottom of the sample during the transition from 0 g to 1.8 g.

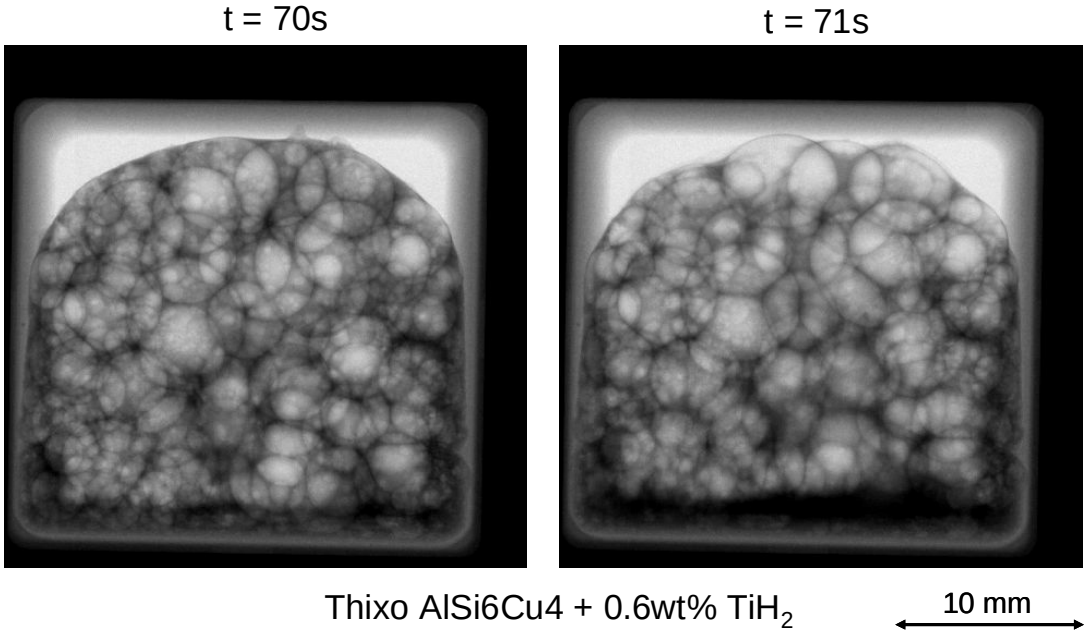

Figure 4: Liquid metal foam without drainage made under microgravity (left) and quick drainage one second later during the transition to 1.8 g (right)

Preparation of the sounding rocket mission (MASER 11)

After the module acceptance review February 2008 the ready module is already mounted and prepared for flight. Reference tests were done by the PI by SSC using the same configuration, samples, temperature profiles, batteries, etc. The results of the tests will be compared with the sample made under microgravity. The flight is scheduled for Mai 2008.

Figure 5: XRMON module for metal foams assembled and ready to fly